Status of the LHCb Experiment

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on behalf of the LHCb Collaboration

Contents

1) Introduction

LHCb is a dedicated experiment at LHC to study CP violation and other rare phenomena in B-meson decays.

By measuring CP violation in B_d and B_s systems, we will determine:

- phase of the B_d-$\bar{B}_d$ oscillation with an improved accuracy

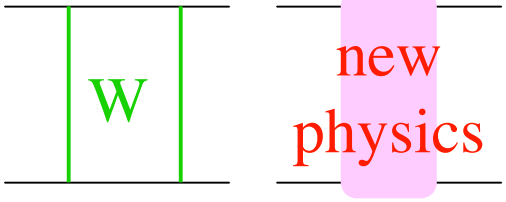
$$\sigma(\sin 2\beta \text{ LHCb one year}) = \int^{2006} \text{Babar+Belle+Tevatron } dt$$

- phase of the B_s-$\bar{B}_s$ oscillation
- phase of the b→s penguin decay
- phase of the b→d penguin decay

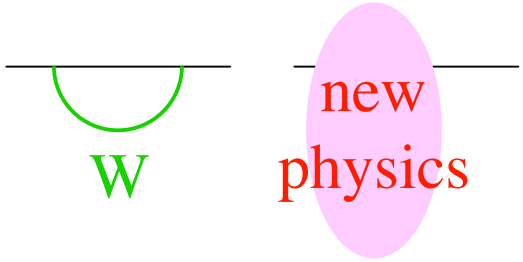
→ Search for New Physics

- phase of the b→u+W^- tree decay → Determination of the CKM

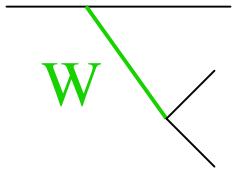
and more…



oscillations



penguin



tree

→ talk by M. Musy

Necessary final states

$B_s \rightarrow J/\psi\,\phi,\ J/\psi\,\eta,\ D_s\,K,\ K^+K^-,\ \phi\,\phi,\ \phi\,\gamma,\ \phi\,K_S,\ \phi\,K^{*0},\ \ldots$

$B_d \rightarrow D^*\,\pi,\ K^{\pm}\,\pi^{\mp},\ \pi^+\,\pi^-,\ K^{*0}\,\gamma,\ \phi\,K_S,\ \phi\,K^{*0},\ K^{*0}\,\overline{K}^{*0},\ \ldots$

LHC Both B_d and B_s

LHCb Hadron PID, trigger sensitive to hadronic states, excellent σ_t

Experiment approved in 1998

Approved Technical Design Reports:

Magnet, Calorimeter System, RICH System, Muon System, Vertex Locator, Outer Tracker, Online System, Inner Tracker

Under construction:

Magnet, Electromagnetic Calorimeter, Hadron Calorimeter

Starting construction soon:

RICH-2, VELO, OT, Scintillator Pad Detector and Preshower (Calo. System), Muon System

TDR's still to come:

Trigger, LHCb reoptimization (2003)

Computing (2005)

Optimal L for LHCb ~ $2\times10^{32}\text{cm}^{-2}\text{s}^{-1}$: physics can be exploited from day one and β^* can be tuned to run also at nominal L.

2) LHCb reoptimization

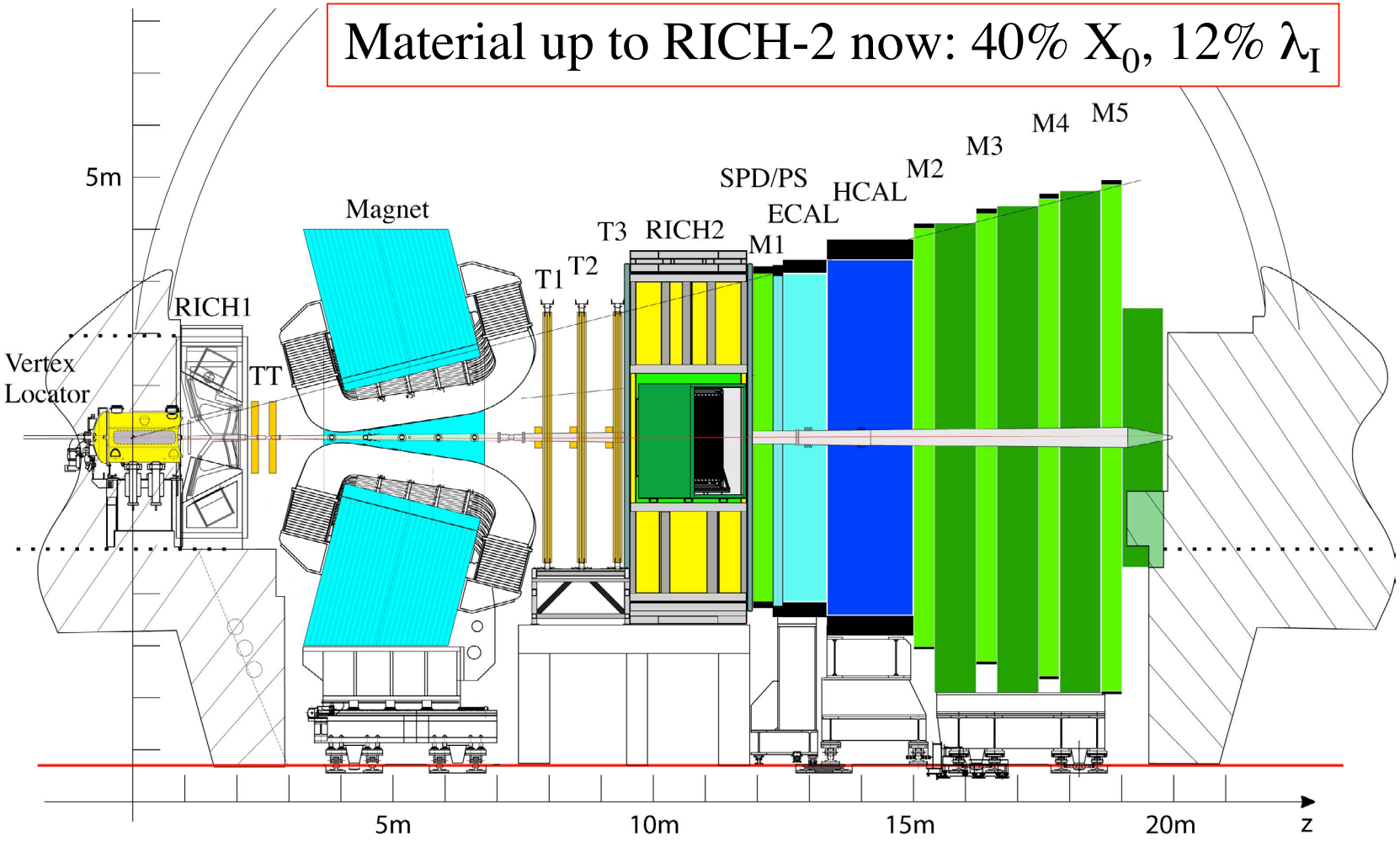
Material reduction:

-Cut the tracking stations by 1/2: e.g. no stations inside of the magnet

-Improved RICH-1 design: e.g. mirror and mirror support

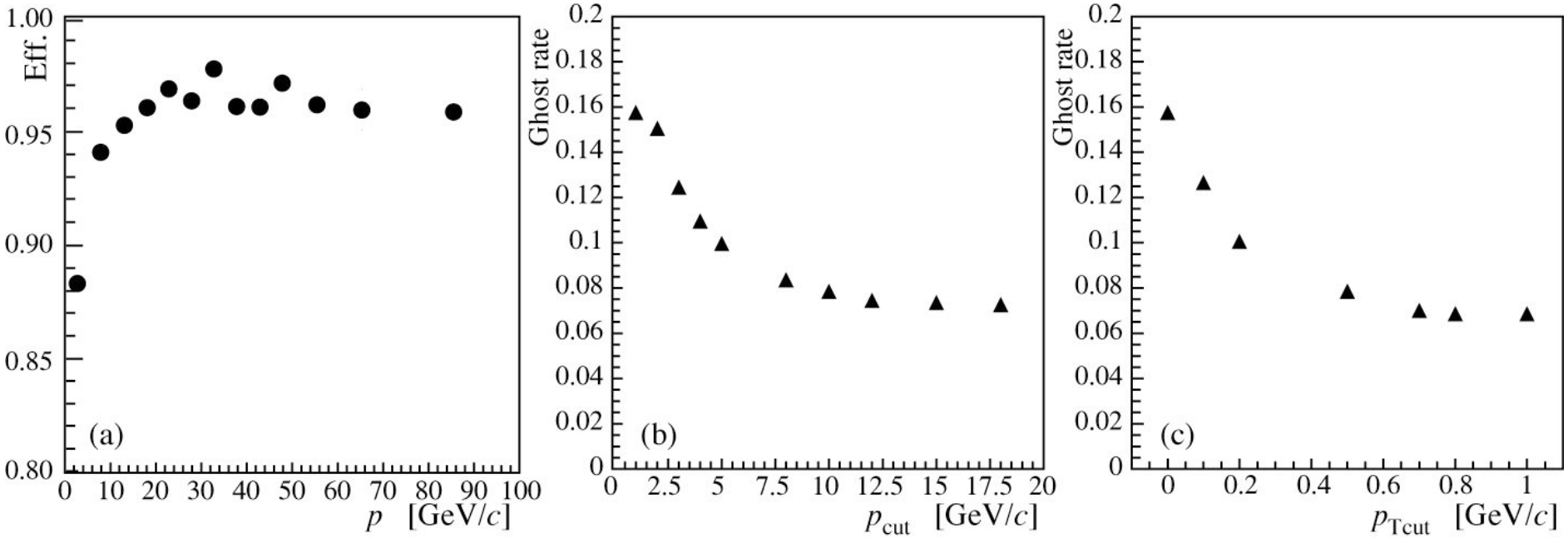
-Improved VELO design: number of Si sensors and their thickness

Material up to RICH-2 now: 40% X_0, 12% λ_I



New tracking configuration does not deteriorate the performance

For tracks which start from VELO and go through T1-T3



efficiency

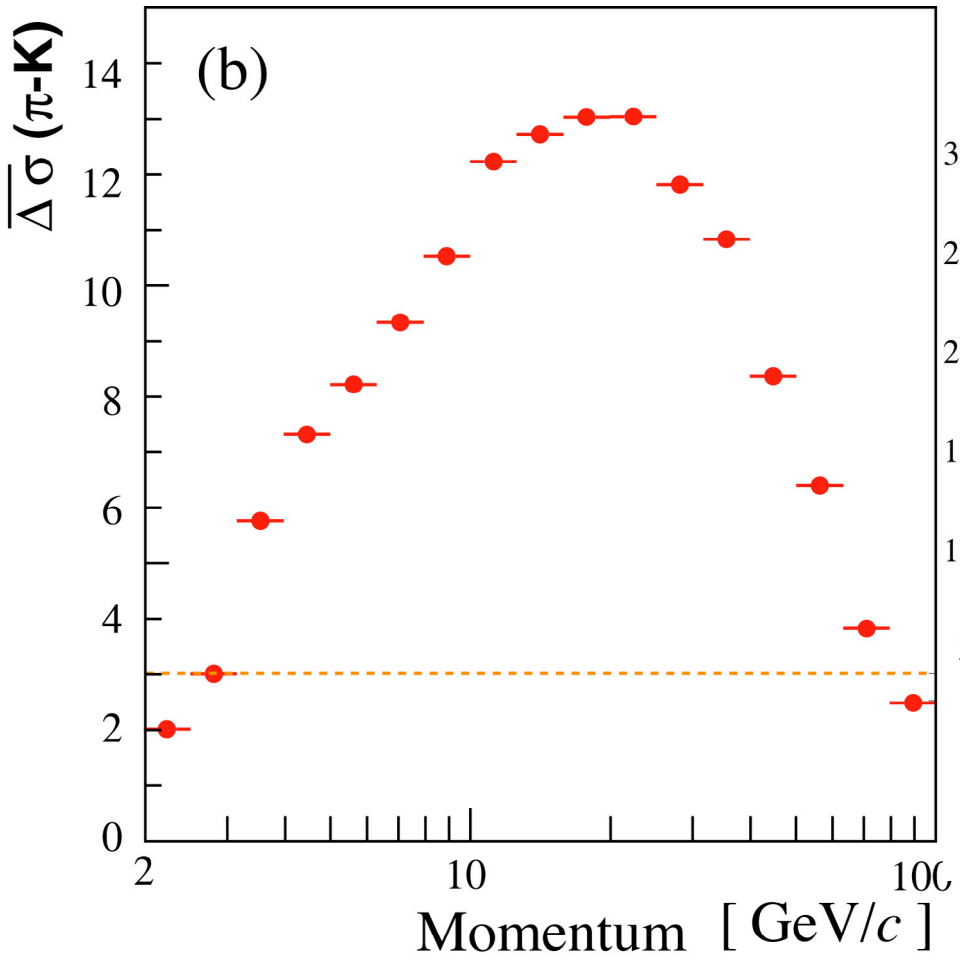
ghost rates

Track reconstruction efficiency 95% for p>5 GeV/c
Ghost rate 7% for $p_T > 0.5$ GeV/c

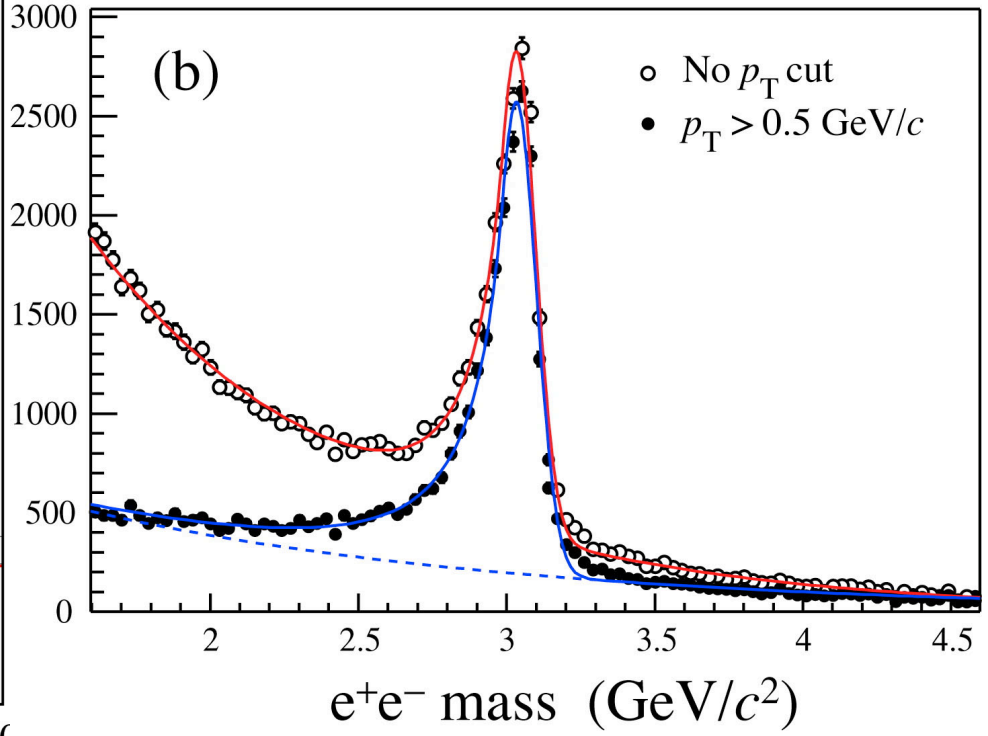
→ talk by J. van Tilburg

Particle ID performance is still good

K/π separation



J/ψ (e^+e^-) peak

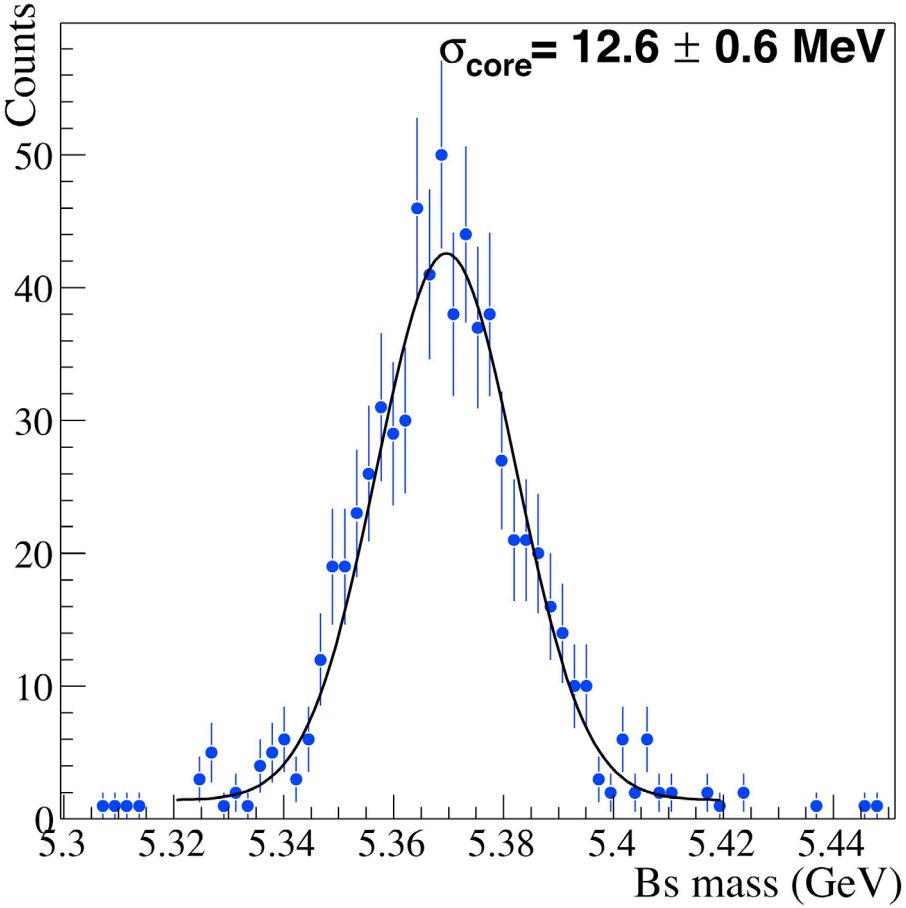


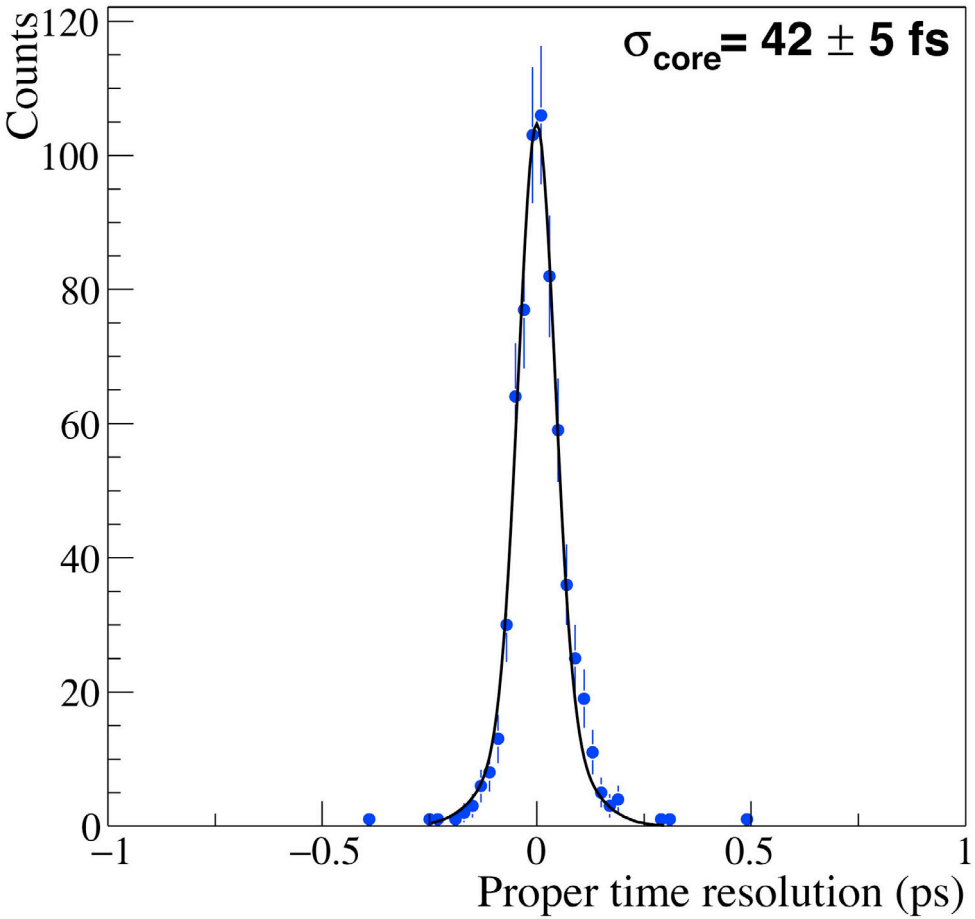
electron reconstruction

→ talk by C. Jones

Final state reconstruction performance is maintained

$B_s \rightarrow D_s \pi$: mass and decay time resolutions





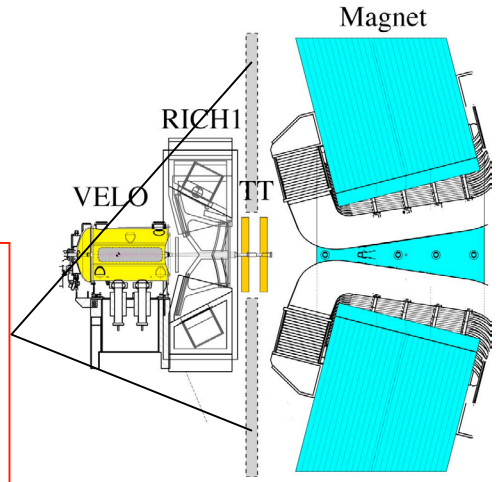
→ talk by M. Musy

Additional change to improve the trigger

Level-0: unchanged

"high" p_T μ, e, h, γ, π^0 + pile-up veto

(Calo, Muon, Pile-up) 40MHz → 1MHz



shielding plates were removed to introduce
B field between VELO-TT
→ p_T measurement with VELO+TT in Level-1

Level-1:

Level-0 information + tracks with high p_T and large impact parameter

(Level-0 decision unit + VELO + TT) 1MHz → 40 kHz

First look at annual yields (untagged sample)

$B_d \rightarrow$	$\pi^+\pi^-$	27 k	$B_s \rightarrow$	K^+K^-	35 k
	$K^\pm\pi^\mp$	115 k		$D_s\pi$	72 k
	$K^{*0}\gamma$	20 κ		D_sK	8 k
				$J/\psi(\mu\mu)\phi$	109 k
				$J/\psi(ee)\phi$	19 k

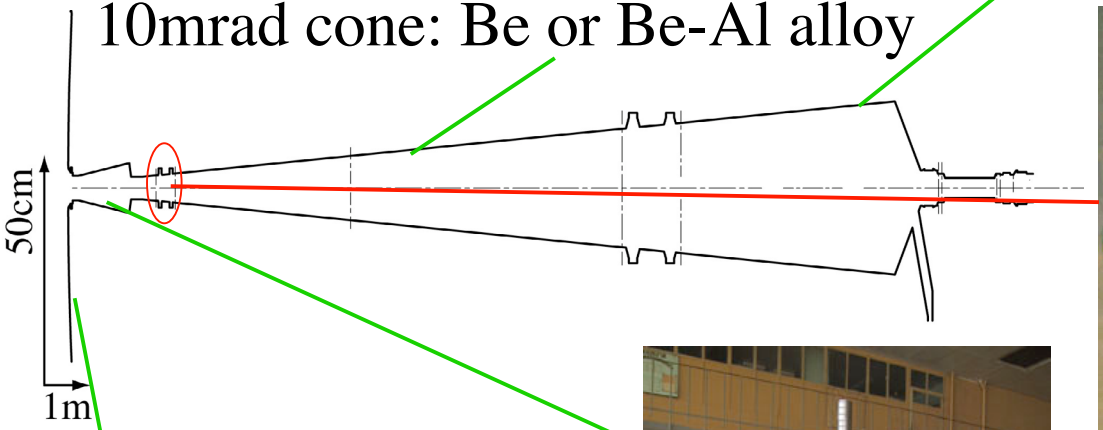
→ talks by A. Satta and T. Schietinger

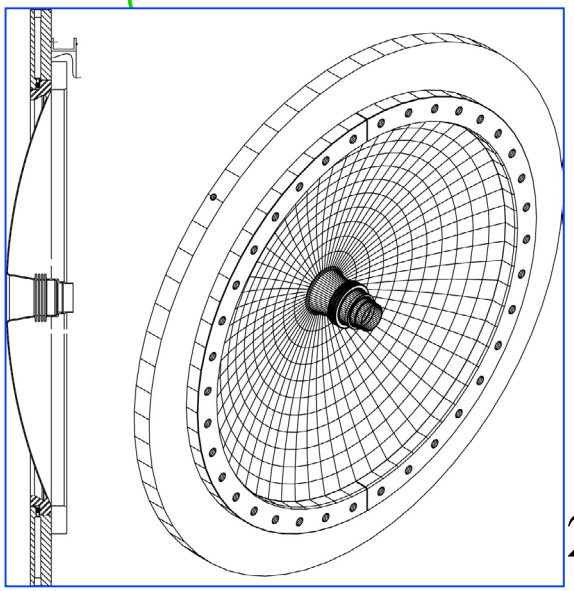
3) Subsystem Status

a) Beam Pipe

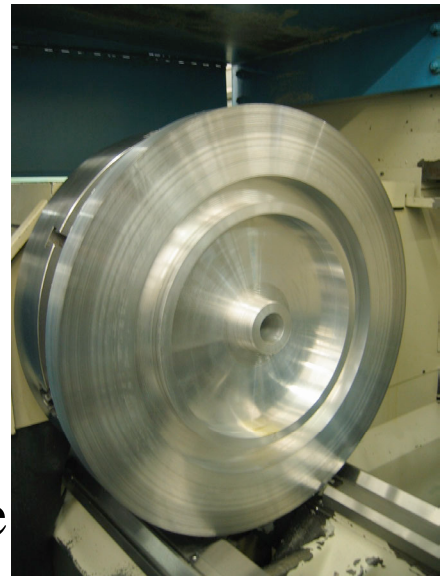
10mrad cone: stainless steel
Al bellows prototype

10mrad cone: Be or Be-Al alloy



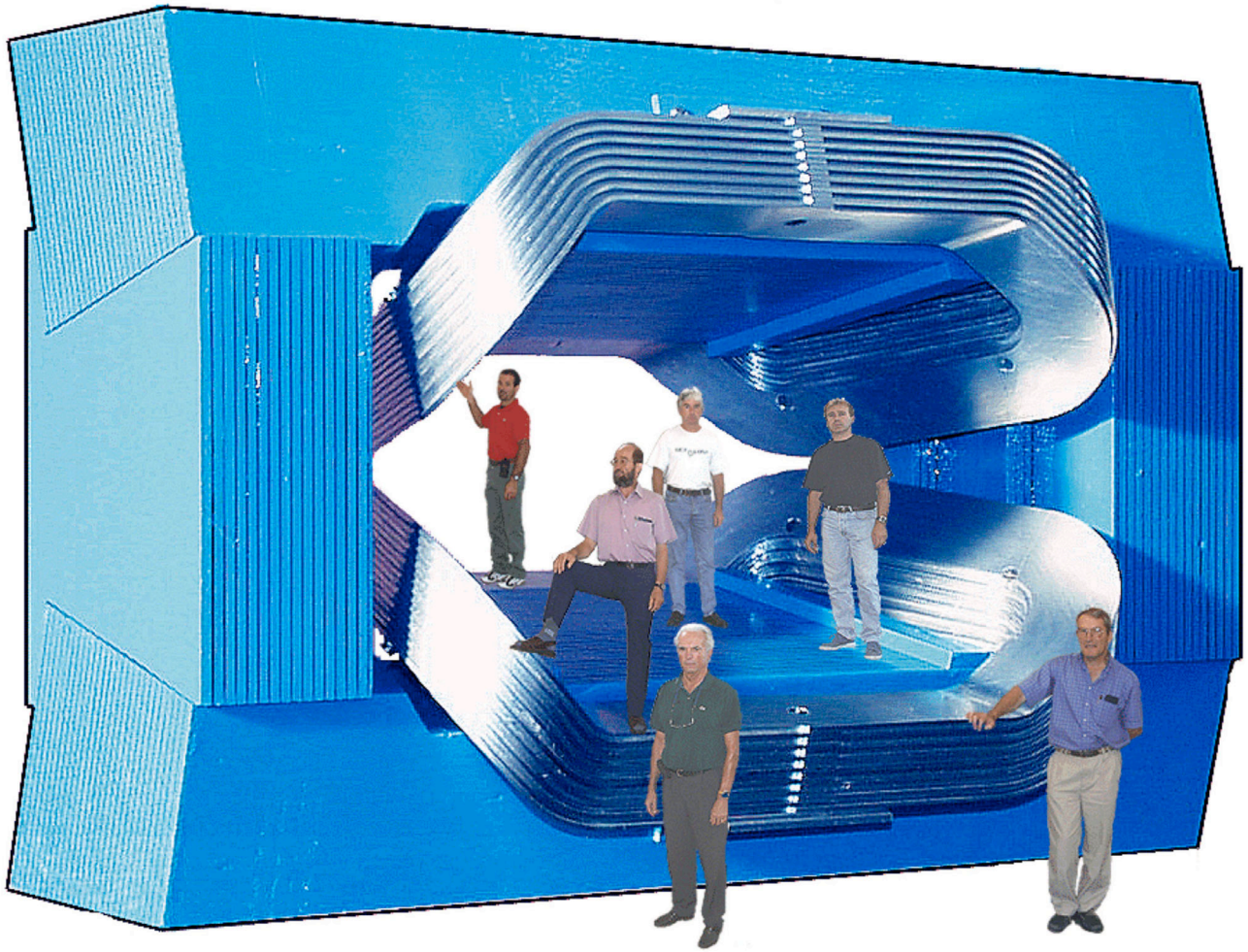


25mrad cone: Be
to be qualified



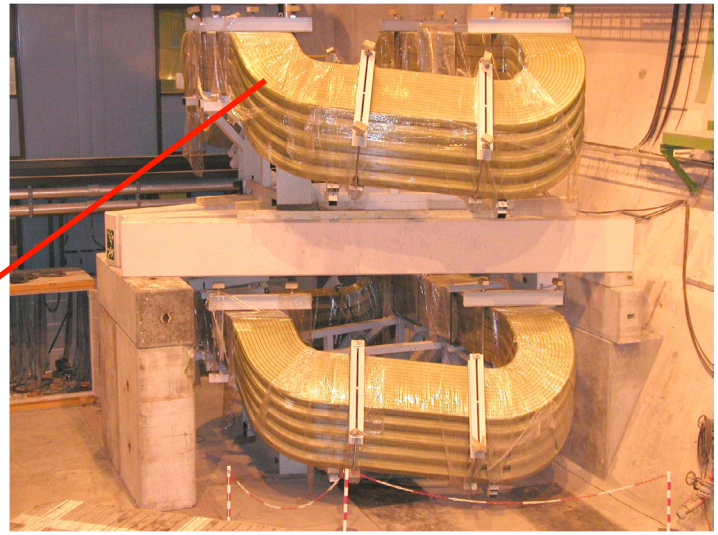
2mm Al exit window being made

b) Magnet

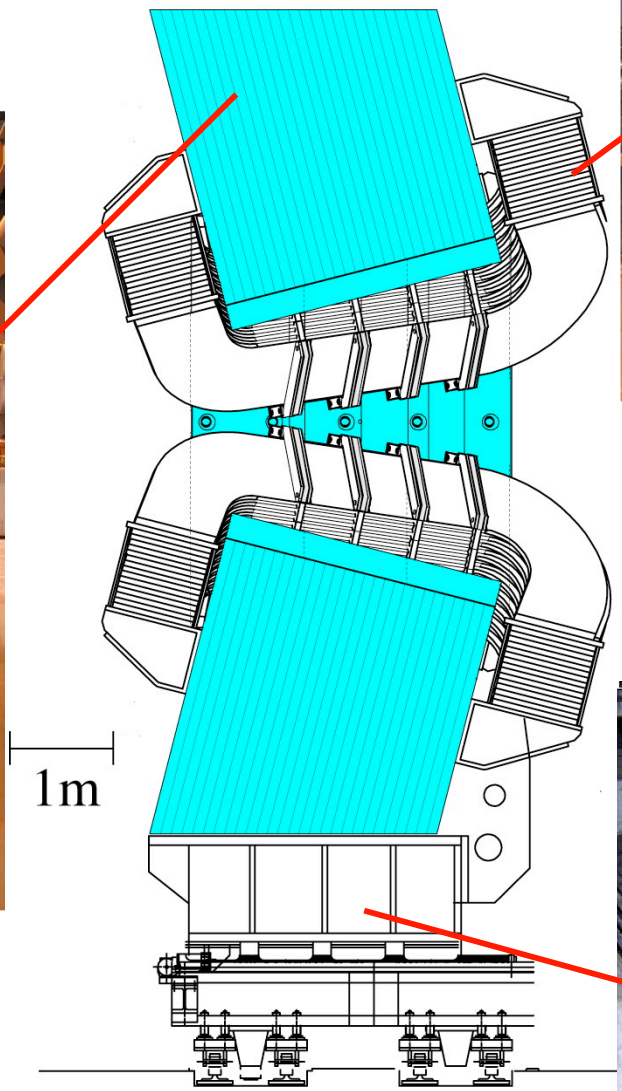


$\int B \, \mathrm{d}l = 4$ Tm
Normal conductor (Al)
Power = 4.2 MW
Fe Yoke = 1600 t

All the coils

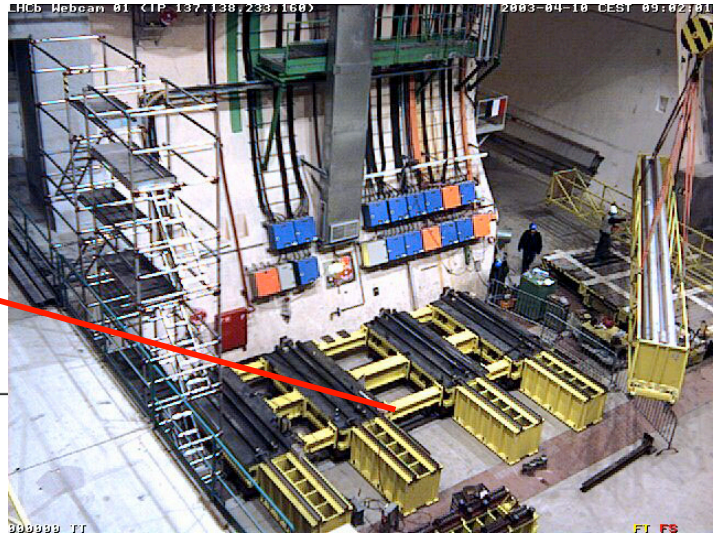


Magnet

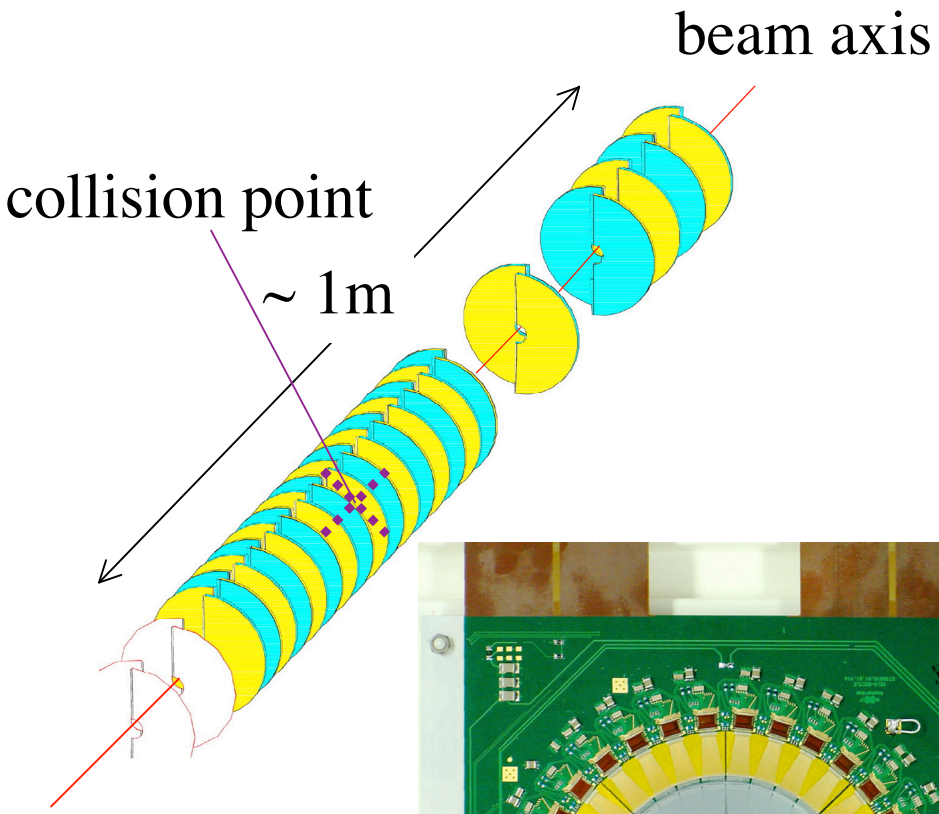


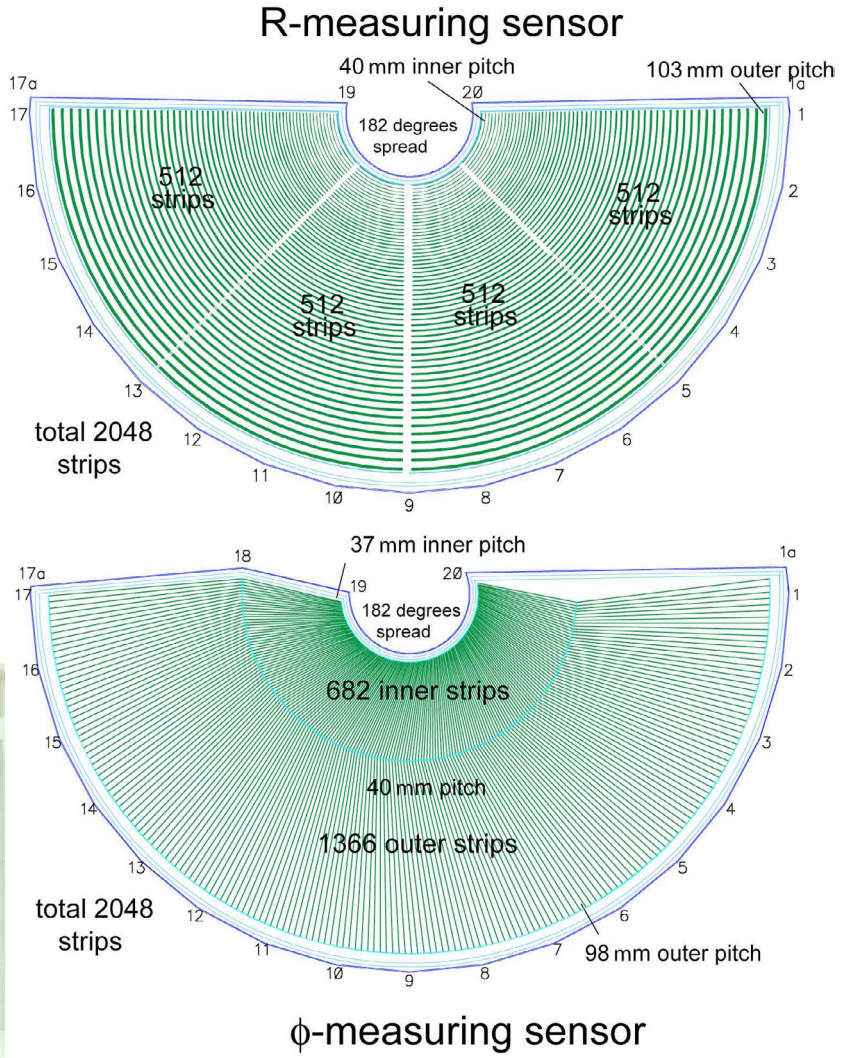
Fe plate for the yoke

Magnet support at UX8



c) Vertex Locator



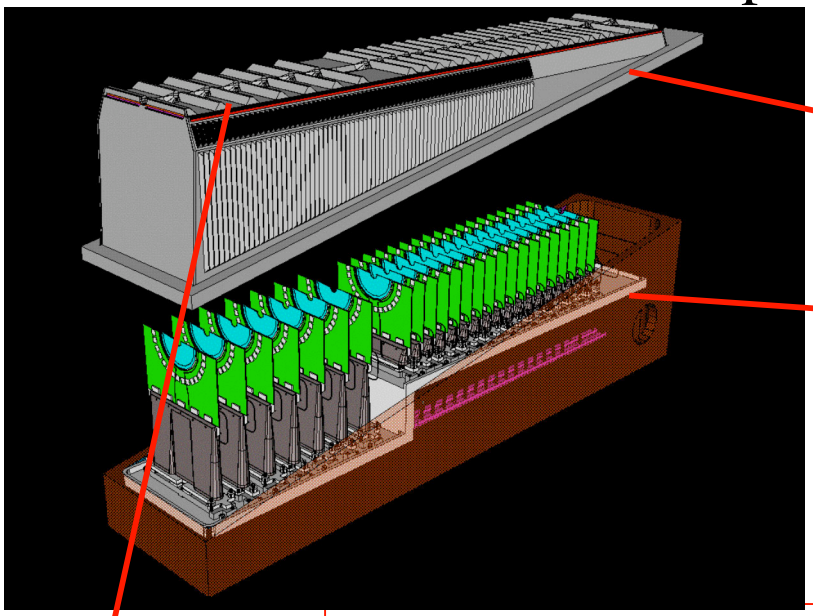


200μm n-on-n Si short strips
double metal layer for readout
with Beetle chip (1/4 μm CMOS)

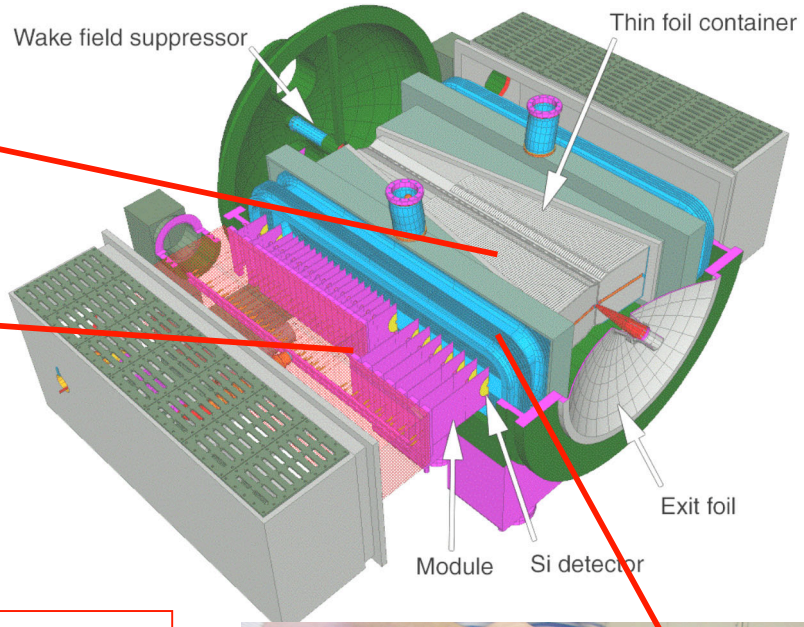
total 172 k channels
occupancy < 1%

They have to be placed in secondary vacuum → complex mechanics

Sensors mounted to a Roman pot system



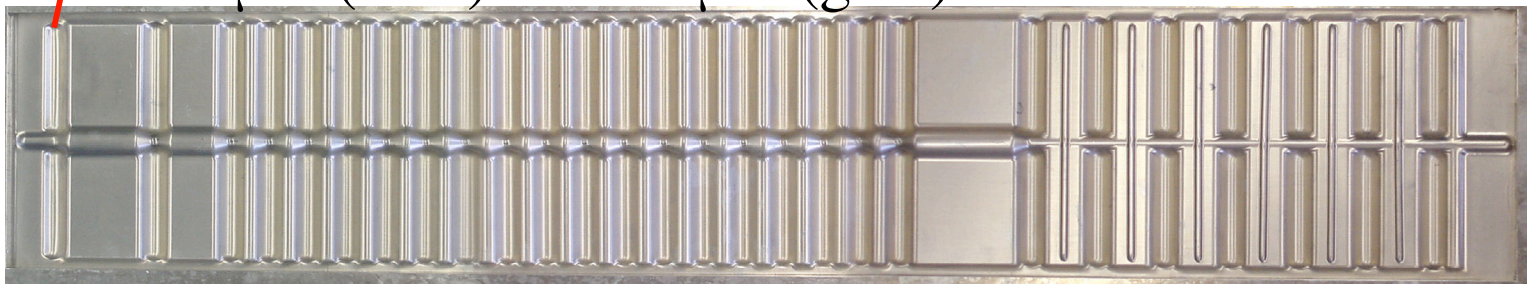
in a vacuum tank



The design has been validated based on the prototype work. Construction will start soon.

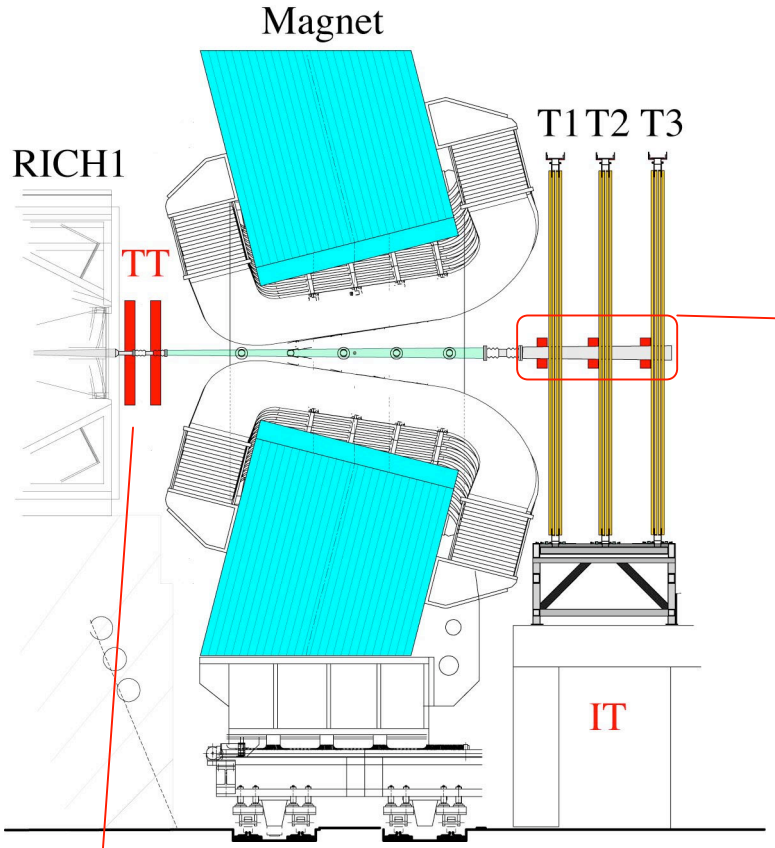
Rectangular bellows

Al RF foil full scale prototype
300 μm (now) → 250 μm (goal)

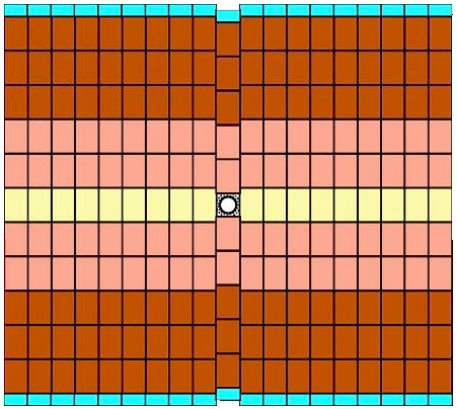


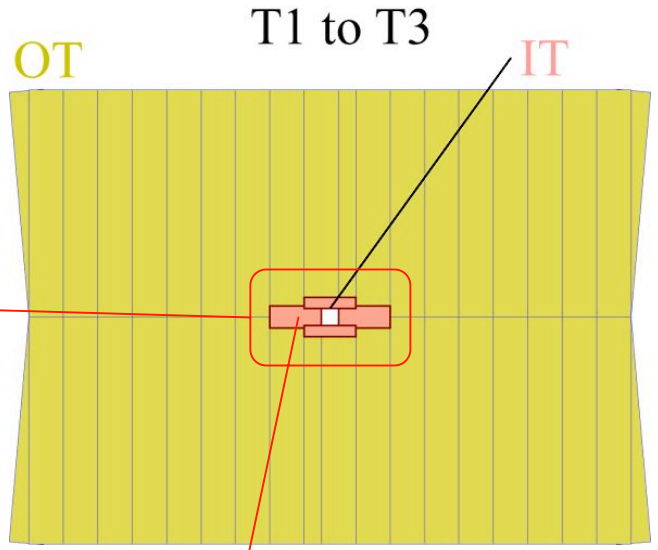
d) Silicon Tracker

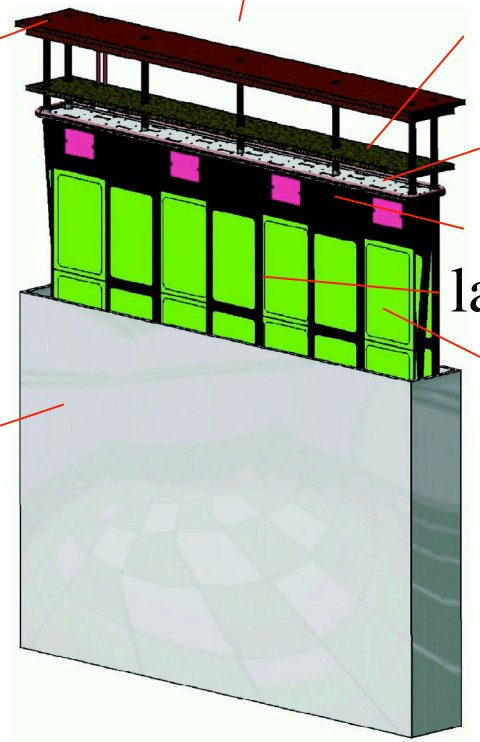
Trigger Tracker and Inner Tracker



~1.4×1.2 m^2





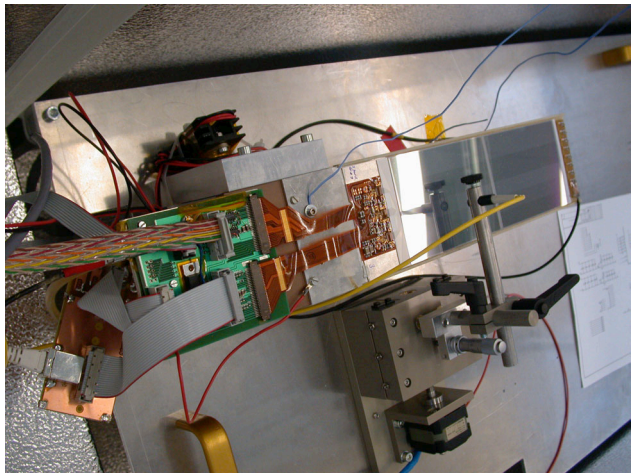


(x-u-v-x) planes

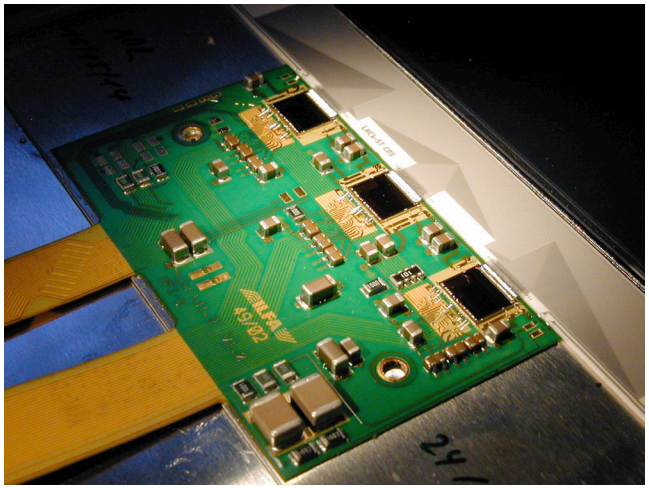
Inner Tracker TDR approved for its Si technology in February 2003

Main effort now is the TT design

Laser test set-up

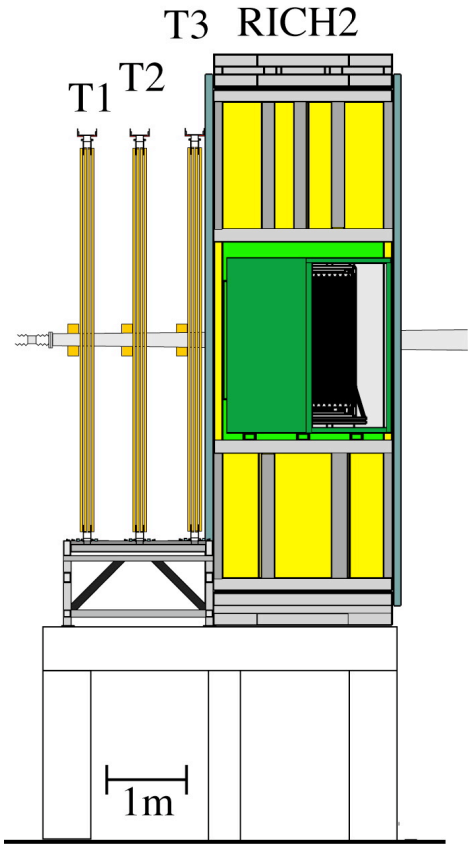


Beetle 1.2 and hybrid



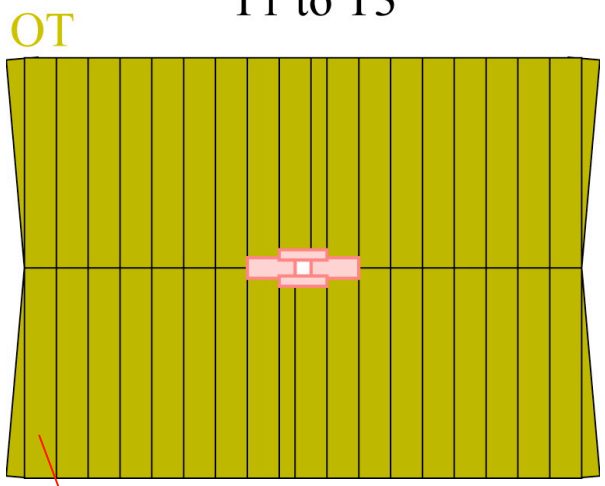
Spring test beam: verify S/N for the long sensor ladder (~30cm) and inter connect cable

e) Outer Tracker



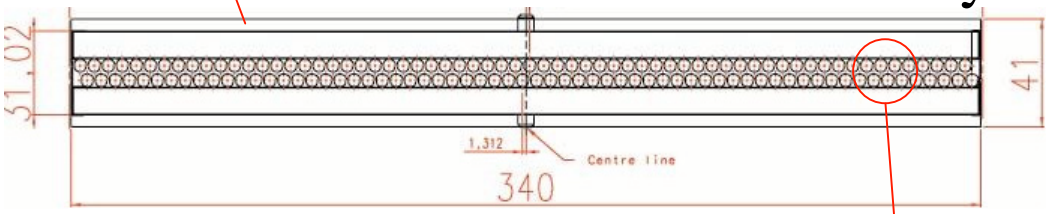
One station = X-U-V-X module planes

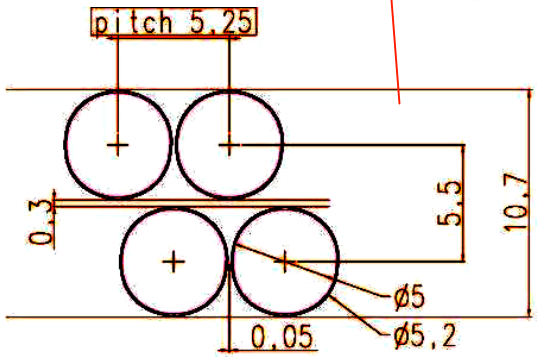
T1 to T3



~6×5 m^2

each module is a double layer

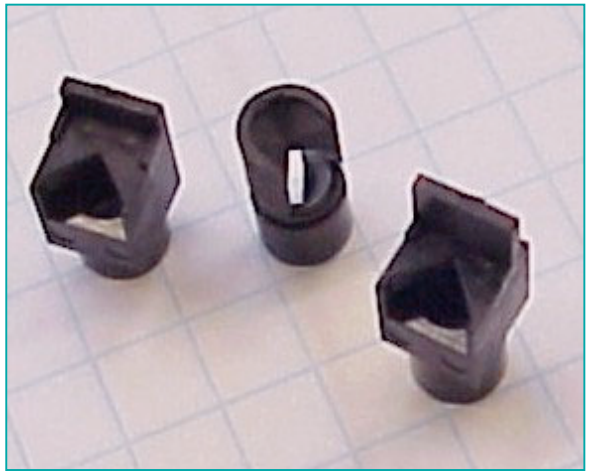




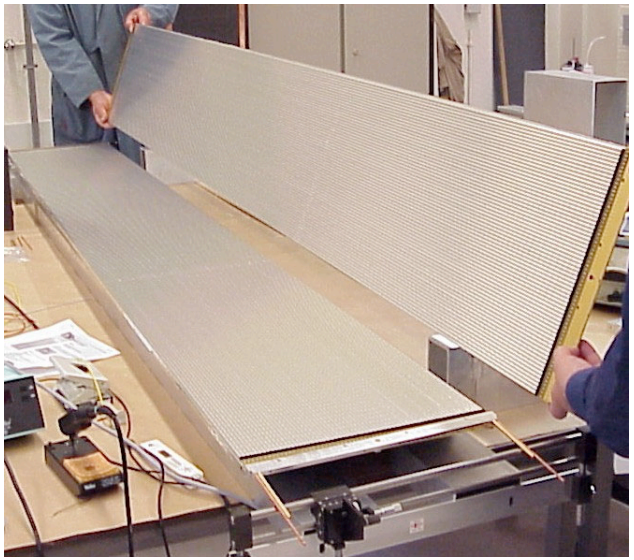
Straw drift chambers

40μm Kapton XC-160

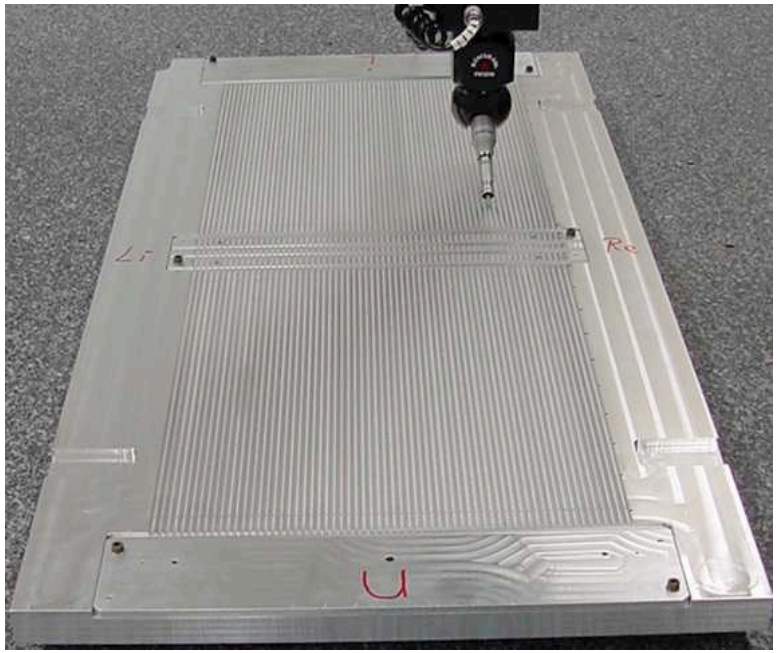
+ Laminated Kapton-Al



wire locators and end piece



2.5 m prototype modules



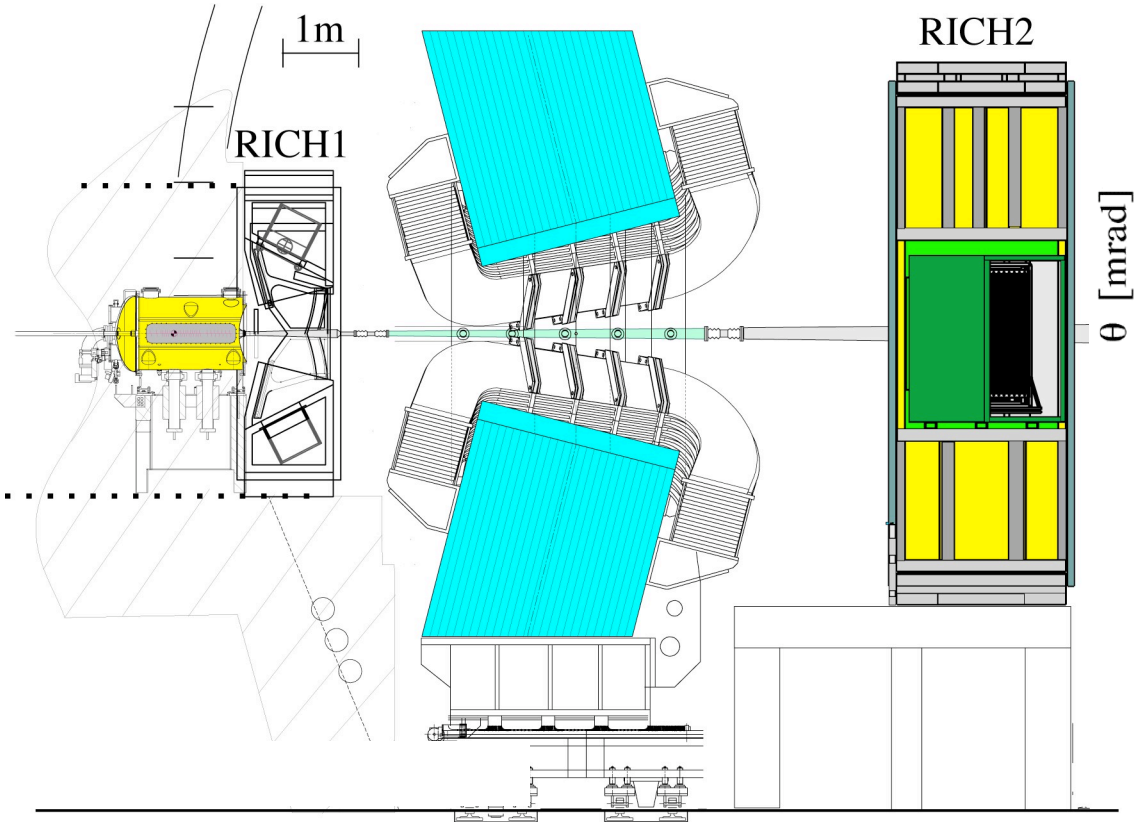
template for the straw assembly

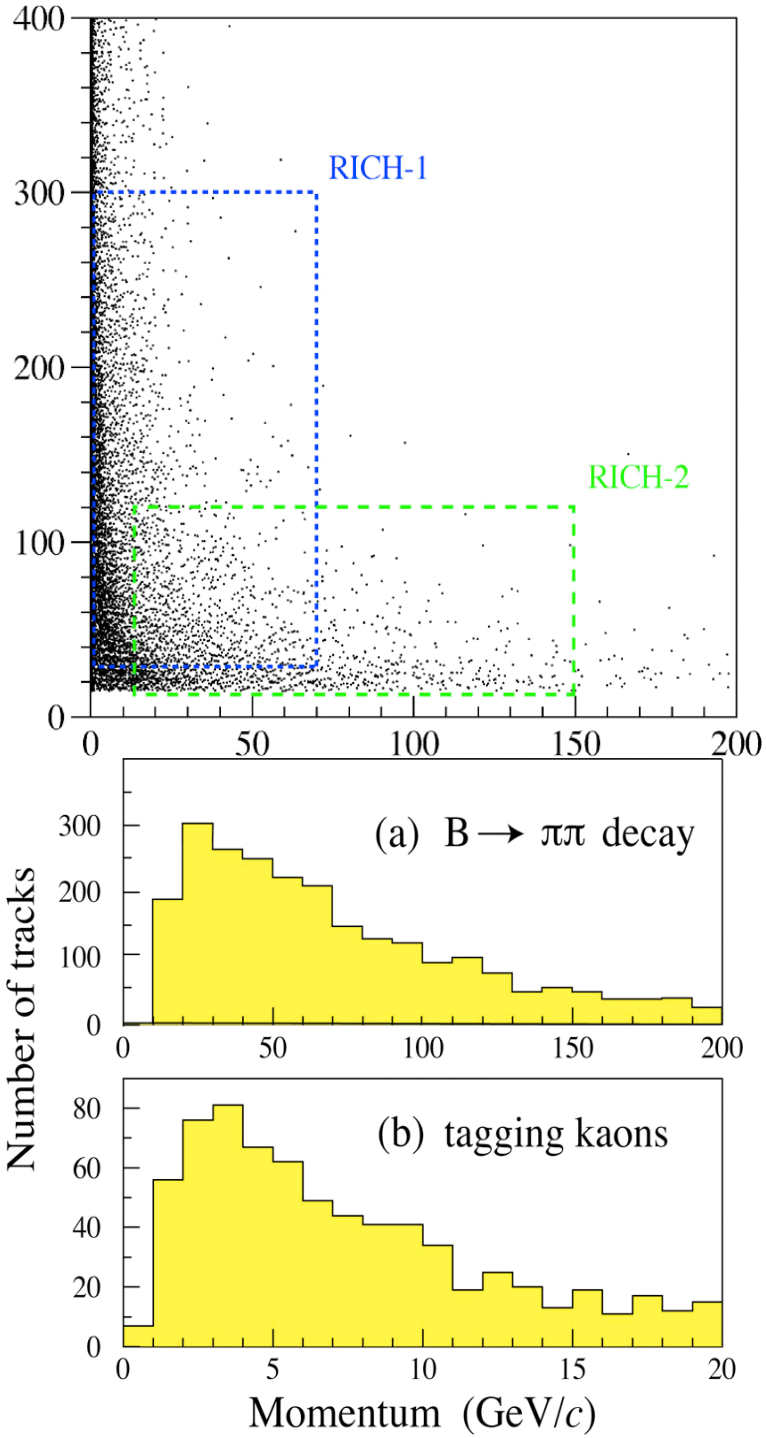
large: l >5 m and

high precision O(10 μ)

Production will start soon

f) RICH





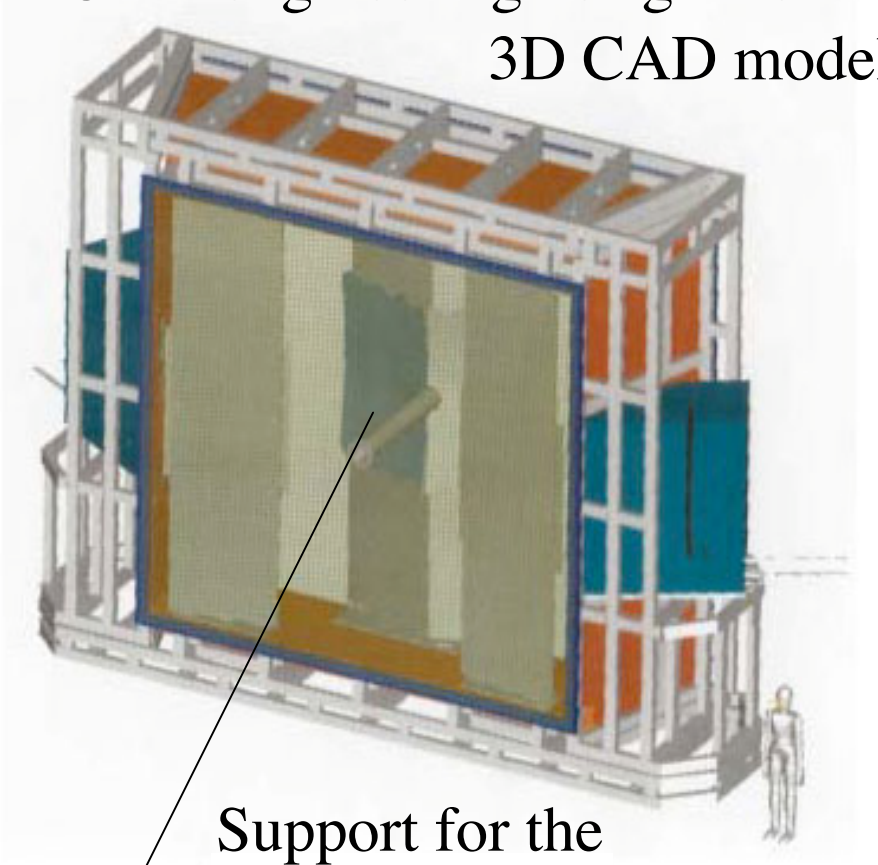
Two RICH with three radiators

Aerogel, C_4F_{10} } RICH-1 (25-300 mrad)

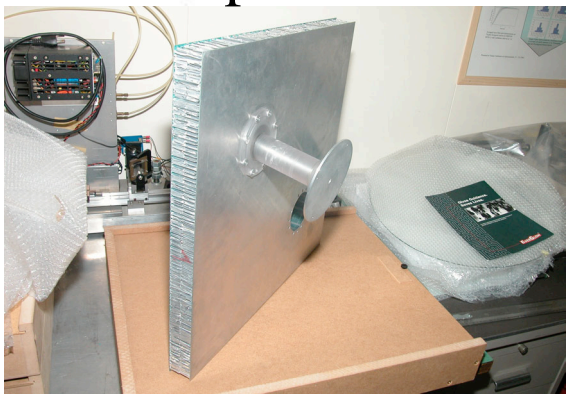
CF_4 RICH-2 (15-120 mrad)

RICH-2 engineering design well advanced

3D CAD model



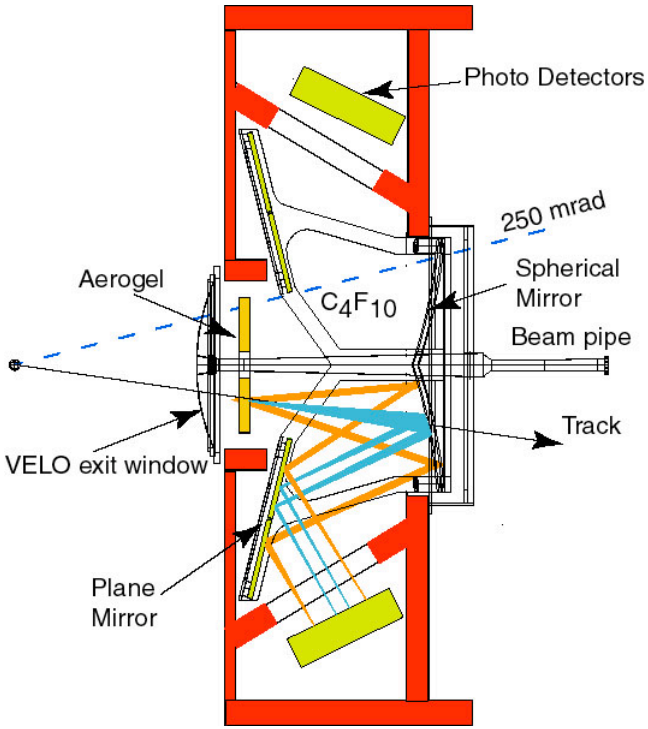
Support for the spherical mirror



RICH-2 construction will start soon.

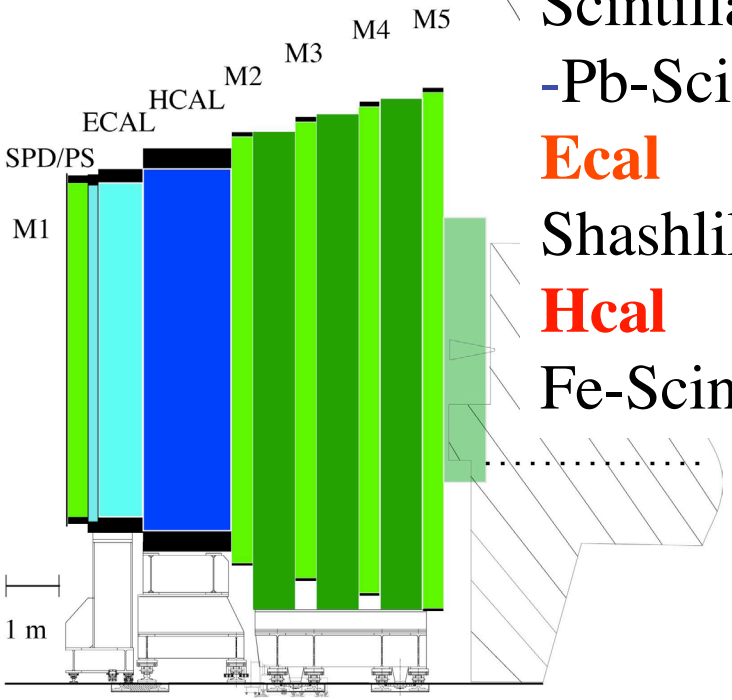
Removal of the shielding plate for the trigger improvement → increased B field @ RICH-1

Redesign needed to protect photon detectors → for the Reoptimization TDR



g) Calorimeters

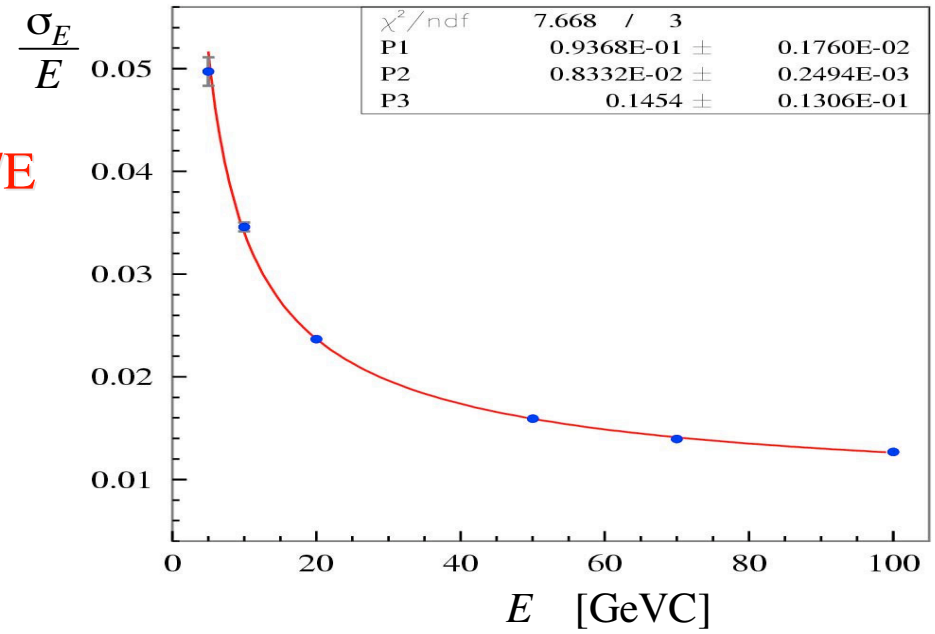
SPD/PS
Scintillator
-Pb-Scintillator
Ecal
Shashlik
Hcal
Fe-Scintillator tile



E-cal production

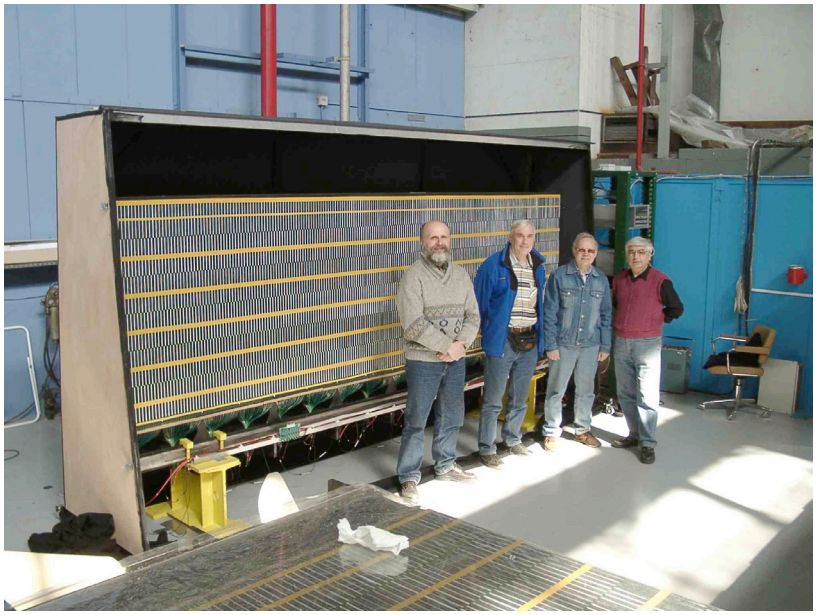
E-cal measured in test beam

$$\frac{9.4\%}{\sqrt{E}} \oplus (0.83\pm0.02)\% \oplus (0.145\text{GeV})/E$$



Production well advanced
70 % of E-cal
15 % of H-cal
modules completed

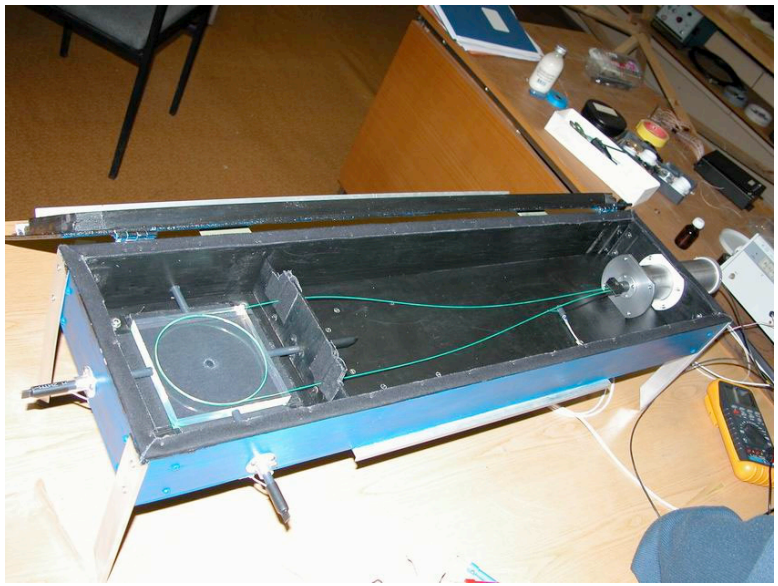
Hcal module assembly



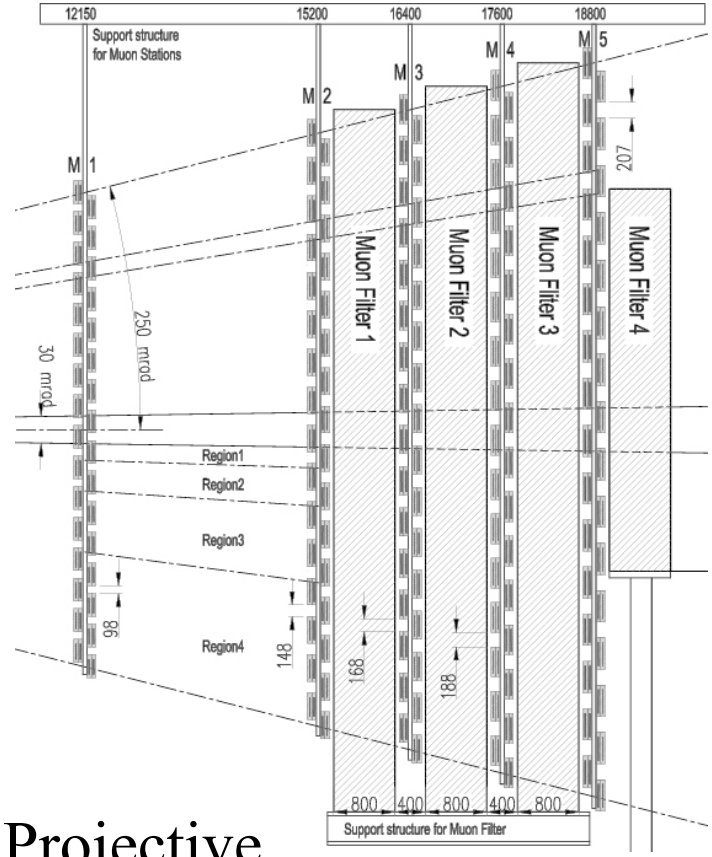
Hcal optics assembly

Preparation in progress for SPD-PS mass production

gluing of fibre in the groove of scintillators

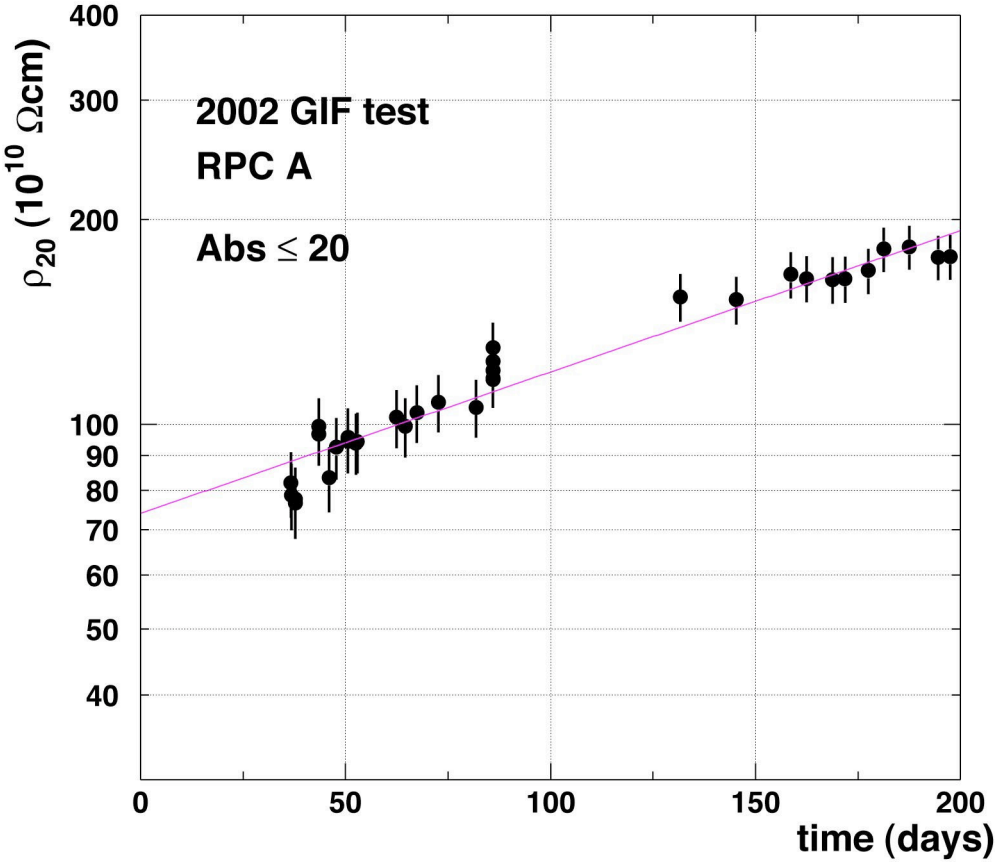


h) Muon system



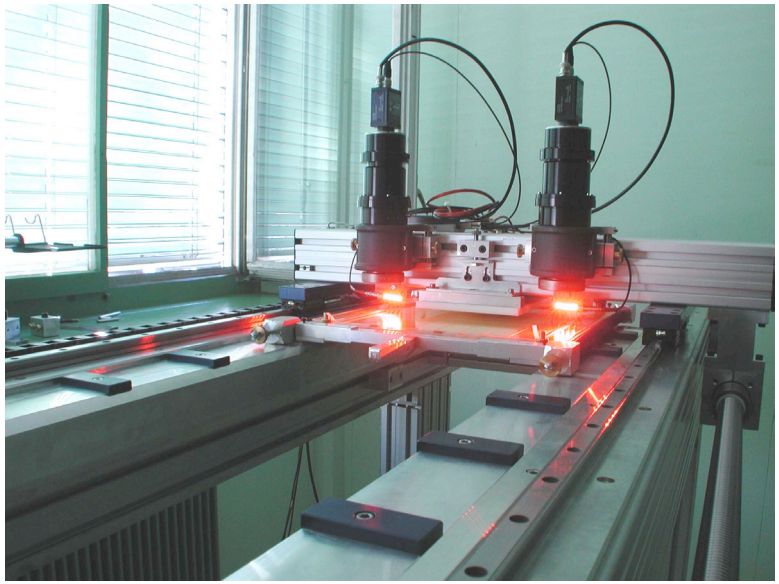
Projective
pad readout
based on MWPC's.

RPC aging test

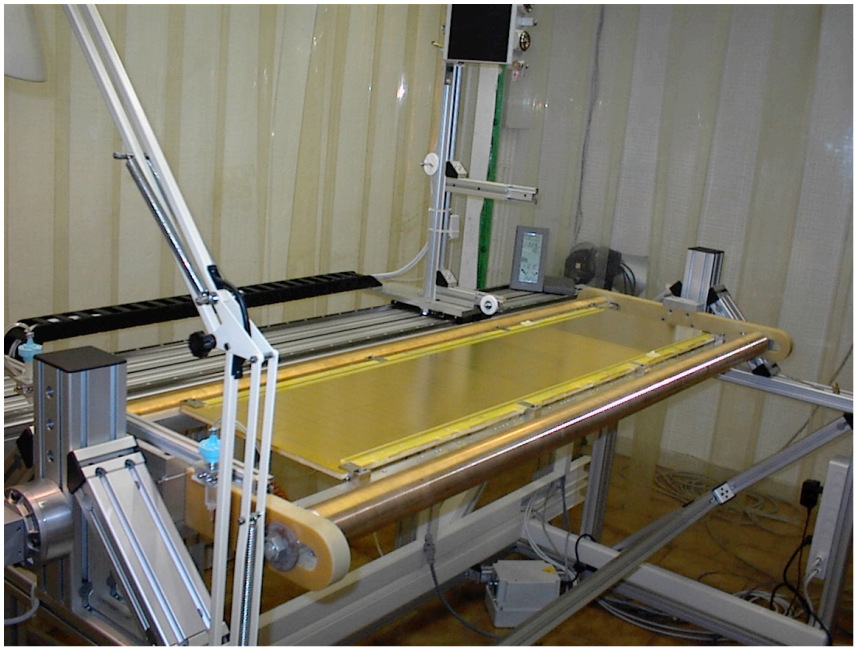


Continuous increase of the plates resistivity resulting in a loss of the rate capability to <100 Hz/cm^2.

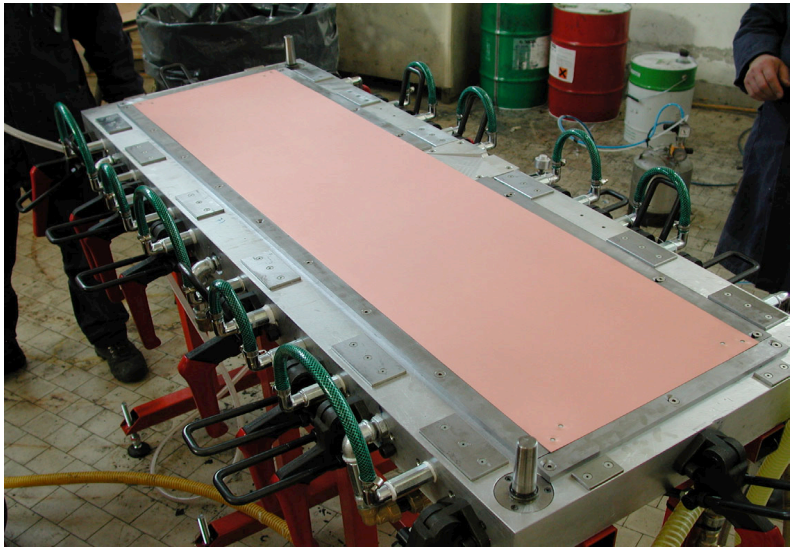
Originally foreseen
MWPC-RPC combination abandoned.



wire pitch measurement machine



wiring machine

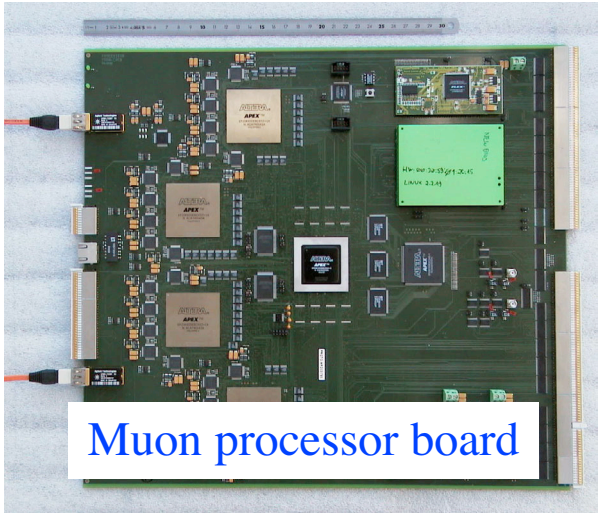


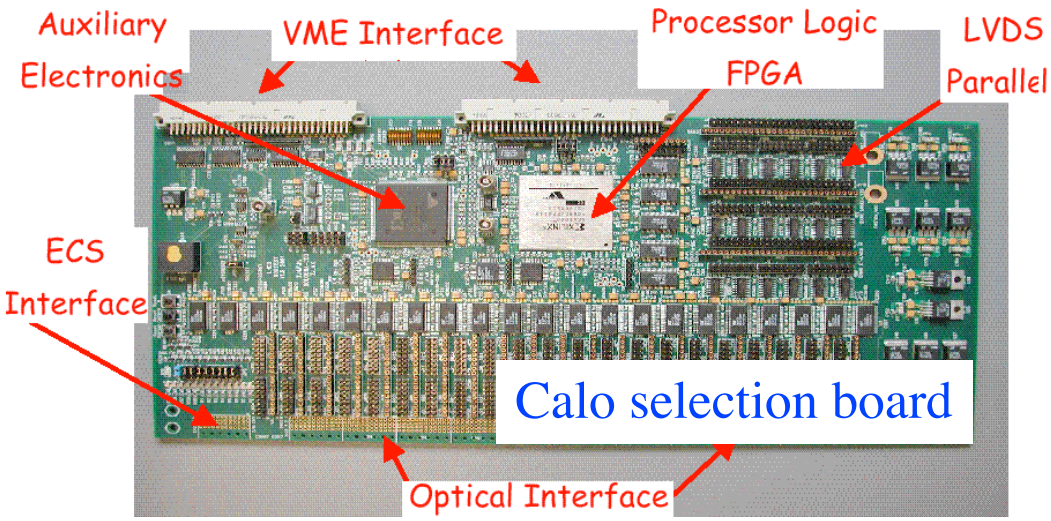
production of panel

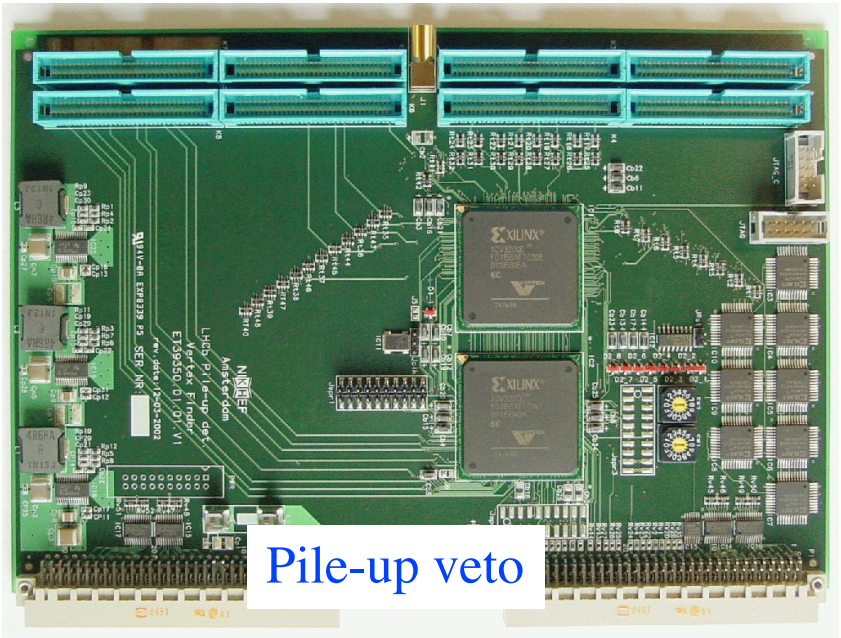
Production of MWPC
will start soon.

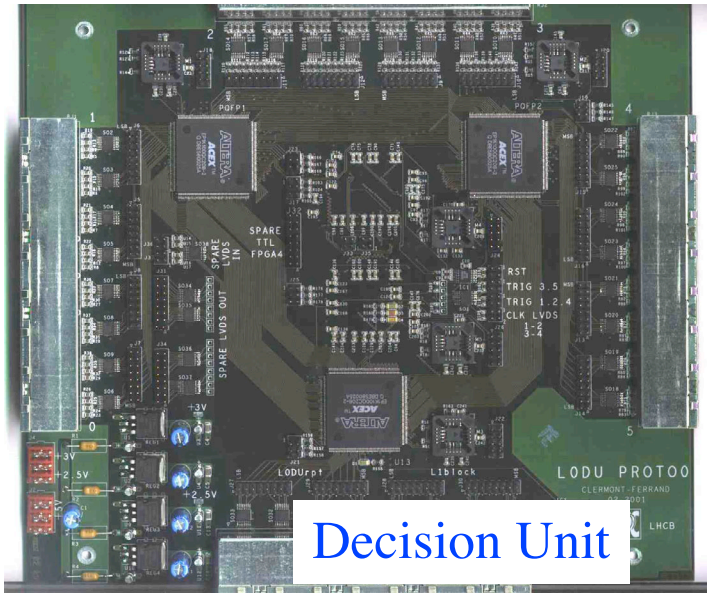
i) Trigger

Level-0: Muon, Calorimeter (e, h, γ, π^0), Pile-up veto, Decision Unit prototype work advancing.







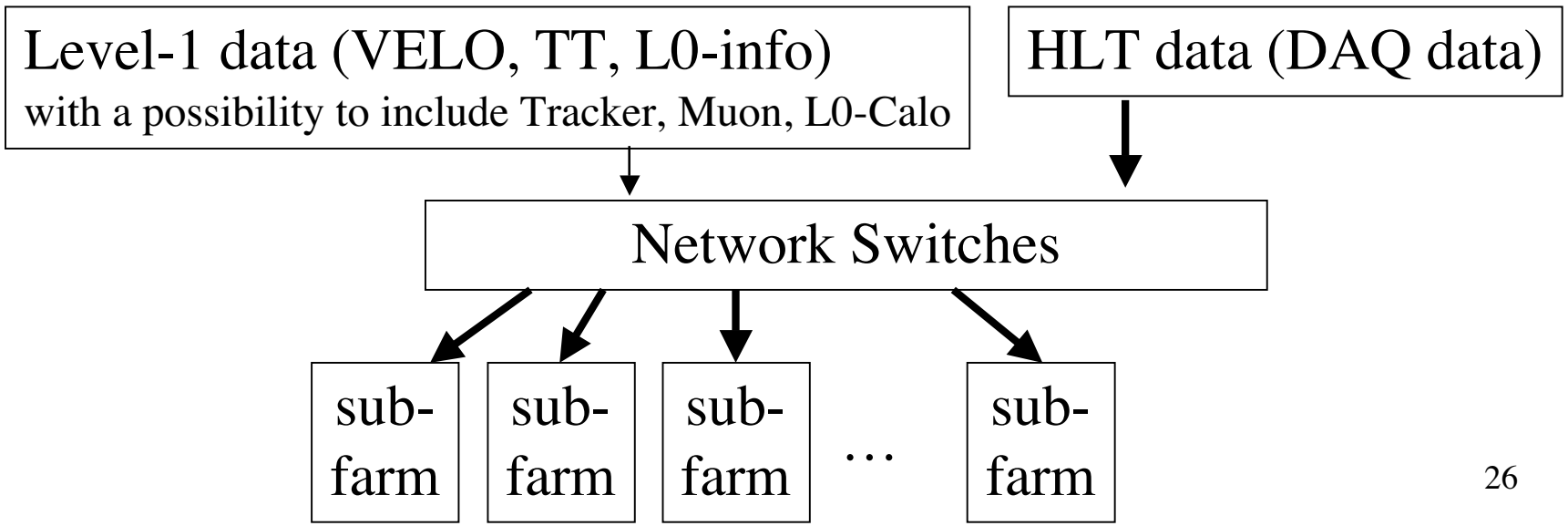


Level-1

Currently data from VELO + TT + L0 Decision Unit
Work on a dedicated Level-1 hardware implementation based on SCI technology completed.
However…

more flexibility in input data and CPU power needed:
keep **a possibility open** to add
IT+OT+Muon+Calo in future
(robustness, evolving physics goal, etc.)

Unified Level-1/DAQ(High Level Trigger) architecture is now studied.



j) Computing

Online DAQ and Experimental Control System

Level-1 accept = 40 kHz

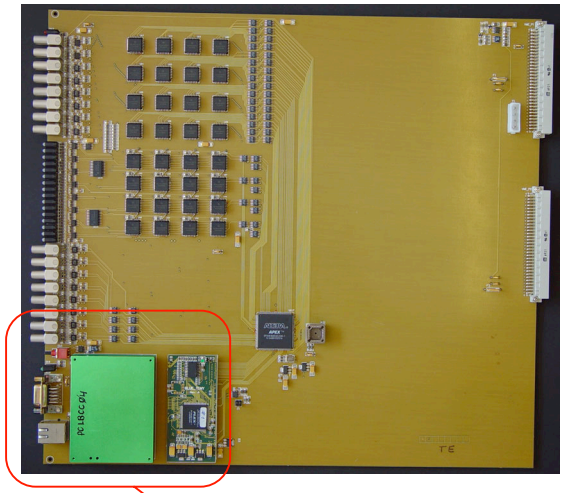
Readout all the detector information for the High Level Trigger processing.

HLT accept = 200 Hz

Record data to mass storage for offline processing.

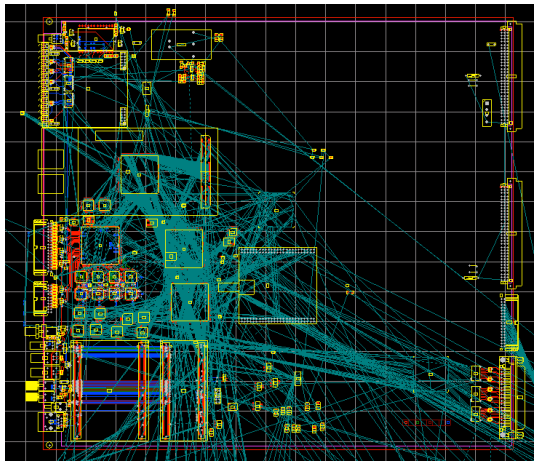
Some prototypes are being built

Timing and Fast Control switch



with Interface to Experimental Control System

Readout Supervisor layout



Offline software

Stable running of

event generation	Pythia	SICBMC (Fortran)
particle tracking through the detector	GEANT3	
detector response simulation	Brunel	almost all in C++
event reconstruction	Brunel	
physics analysis	DaVinci	

for the Trigger and Reoptimization TDR's

Current activity:

Brunel → event reconstruction only

and new package for the particle tracking and detector response based on GEANT 4 (Gauss)

Offline computing

Development of the LHCb computing model

gaining experience from the large scale MC event generation

~1M events/day for the Trigger and Reoptimization TDR's

using CERN + many other institutes + European Data Grid

A total of >40M events generated:

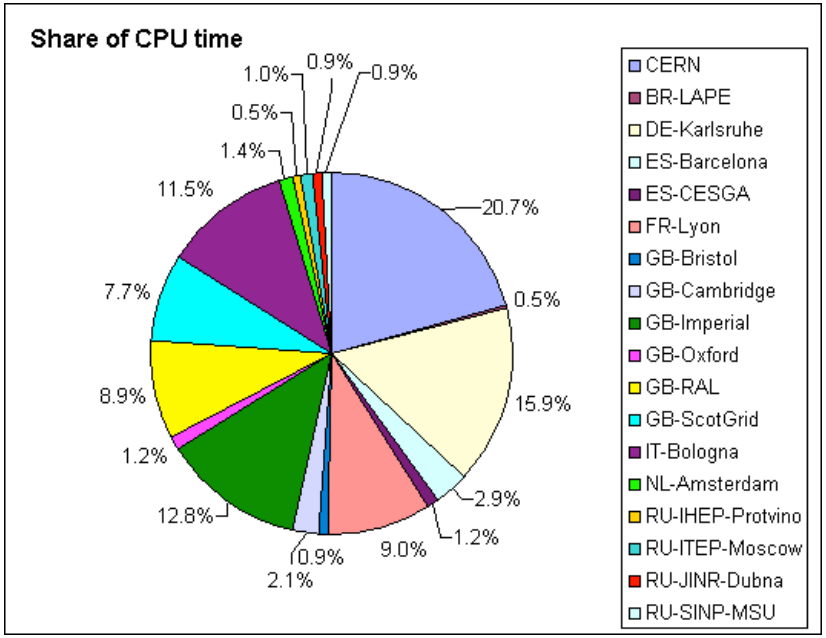
30M Minimum Bias events } trigger study

+ specific B decay samples

10M bb inclusive } physics performance study

→ data reduction is being made to cope with the amount

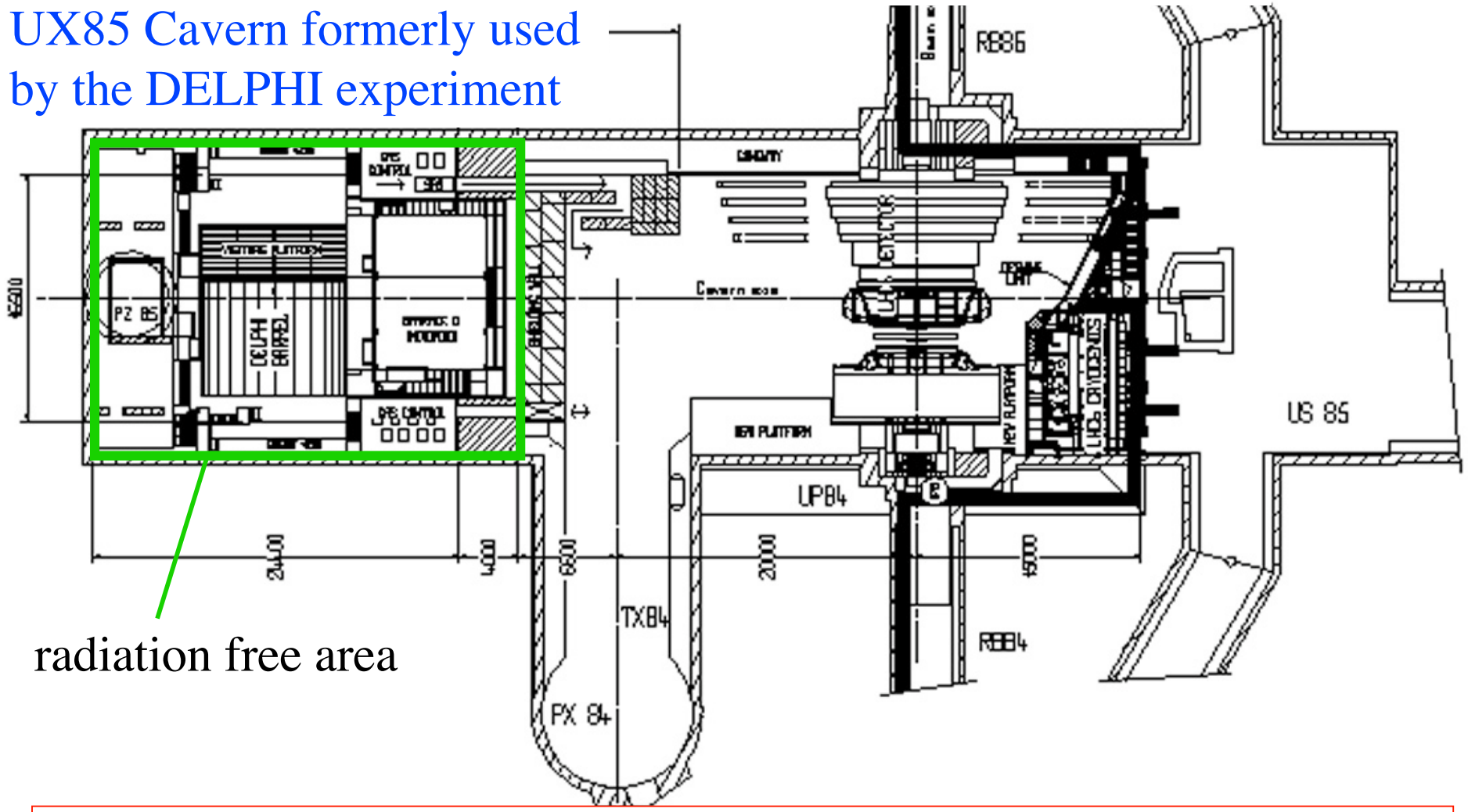
Production shared among
18 computing centres



NB
~190 sec/B-event with 1 GHz Pentium VI
10^5 B-events/sec at LHC

4) Experimental Area

UX85 Cavern formerly used
by the DELPHI experiment



radiation free area

All the subsystem installation to be completed by Summer 2006, giving sufficient time for the global commissioning for the first beam in April 2007.

5) Summary

- Construction of the magnet, E-cal and H-cal modules is progressing as planned.
- Good progress on the detector reoptimization. A simpler tracking system with good physics performance. Trigger is becoming more robust and efficient.
- Construction of VELO vacuum tank, RICH-2, OT, SPD/PS and Muon chambers will start very soon.
- The LHCb collaboration expects to complete the detector commissioning by April 2007 to be ready for the first LHC beam.